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UF UNIVERSITY of FLORIDA IFAS

CARBON SEQUESTRATION

FROM THE CHAIR

The major challenges for Florida's landscapes are: (1) meeting critical environmental regulations related to water quality while maintaining economic productivity, (2) decreasing the rate of soil degradation and ameliorating degraded soils, and (3) protecting the quality of natural resources. Soils function as sinks or sources for various contaminants including: nutrients, trace metals, human and animal pathogens, pesticides, and other toxic organic compounds of agricultural and industrial origin. Land use changes and alterations in management practices have significant impacts on soil quality and ultimately affect the quality of groundwater, adjacent streams, wetlands, lakes, and estuaries. In addition, land use changes and other human activities also are altering the chemical composition of the atmosphere through enhanced production of greenhouse gases such as carbon dioxide, methane, and nitrous oxide. On a positive note, soils are known to be effective in carbon sequestration and serve as major reservoirs for carbon.

Given the unique landscape, climatic/hydrologic and land use conditions, Florida soils have a larger carbon sequestration potential than most other states. Thus, it is critical to assess soil carbon stocks across Florida and their carbon sequestration potential to provide input for evolving carbon trading systems and markets. Recently, Governor Crist provided leadership in signing an executive order to set targets of reducing Florida's greenhouse gas emissions, setting new standards for use of renewable energy sources, and considering a system allowing entities emitting greenhouse gases to buy credits from entities that are reducing emissions. Florida soils could be such an entity to sequester carbon thereby offsetting rising global carbon dioxide emissions. We are challenged to develop a Florida carbon budget and gain a better understanding of carbon cycling across Florida's complex soil-landscape.

The research and educational activities of the Soil and Water Science Department (SWSD) have broad applications to water quality, carbon sequestration, and climate change. Our faculty are taking a holistic, integrated approach to research and education to address broader issues related to soil and water quality, carbon sequestration, and production of greenhouse gases. In this newsletter, we highlight some of the research and education activities related to carbon sequestration. A core group of SWSD faculty have formed a working group to review current research on soil's role in carbon sequestration and explore potential funding opportunities. The efforts of this group are led by **Nick Comerford**, who has a long track record of studying carbon sequestration in forested ecosystems.

Dr. K. Ramesh Reddy, Chair, Soil and Water Science Department, 106 Newell Hall, Box 110510, University of Florida, Gainesville, Florida, 32611. Telephone 352-392-1803; Fax 352-392-3399. Email: krr@ufl.edu http://soils.ifas.ufl.edu

Soils as Reservoirs of Carbon

Florida has the highest soil carbon density (g C km^{-2}) in the continental United States and ranks near the top among all states in its total soil carbon storage. Even with these impressive metrics, SWSD researchers are working to better document and predict the soil carbon storage, sequestration and mineralization from molecular scale to soil pedon to the landscape. These activities, while focused on Florida, also include research extending to Europe, Southeast Asia, and Brazil.

One of the SWSD's long-term goals is to measure the soil carbon change in the landscape. Practically speaking, that means that the carbon change in the landscape must be large in comparison to measurement error. Therefore, accurate measurement of soil carbon is necessary; or those soil carbon pools that are most sensitive to change must be identified, isolated and measured. Total carbon is fast and easy to measure in many of Florida's soils, but small changes can be difficult to document. In upland soils, soil carbon is sequestered by interaction with clay, occlusion within soil aggregates, deposited or added in forms that are recalcitrant, complexed with aluminum and/or movement to depth were there is reduced decomposition. Sandy surface soils have little clay and do not have macroaggregation.

Central Ridge. Soil Carbon below the surface 2 m profile is not sampled during the soil survey. (Photo Credit: Willie Harris)

It is also known that much of Florida's soil carbon is not in the sandy surface soil, but found in the subsoil. A significant question remains: How much soil carbon is stored below the soil depths we typically measure? That question is best illustrated with a picture of a central ridge soil. The soil depth that is typically described and where soil carbon is measured, the surface 2m, is above the large soil carbon accumulation one sees in the subsoil of this landscape. So how much do we really know about carbon storage in Florida's soils? For additional information, contact Nick Comerford at nbc@ufl.edu.

Biochar as a Soil Carbon Amendment in the Amazon of Brazil

The use of charcoal made from plant material (biochar) is an application of relatively recalcitrant carbon to soil for the dual purpose of sequestering carbon in the soil and increasing crop growth. Nicholas Comerford, a collaborator on the research team of Dr. Newton Falcao, scientist from the National Institute of Amazonian Research (Manaus, Brazil), has been involved in ooking at the phosphorus sorption issue. This team, through the efforts of graduate students and international collaborators, has documented the significant P sorptive capacity of biochar and shown that the phosphorus sorption capacity of recently produced biochar is superior to the biochar found in Dark Earth soils (Terra Preta do Índio) of the Amazon. For additional information, contact Nick Comerford at nbc@ufl.edu.

Join us at ..

The 8th Annual Soil and Water Science Research Forum

The 8th Annual Soil and Water Science Research Forum (**http://soils.ifas.ufl.edu/forum/**) is scheduled for **September 14, 2007**, in Gainesville, Florida. The forum is designed to bring together representatives from state and federal agencies as well as private industry, faculty and graduate students, and prospective students interested in soil and water science. The forum will provide an opportunity for all those interested in soil and water science to interact with our students, faculty, and administrators on campus. This year, **Dr. Kenneth Nealson**, Wrigley Professor of Geobiology, Department of Earth Sciences, University of Southern California is the featured keynote speaker at the forum. We look forward to your participation in the forum. If you are planning to attend, please register at **http://soils.ifas.ufl.edu/forum/**. For additional information, contact Lena Ma at **lqma@ufl.edu**.

Soil Spectral Sensing for Prediction of Soil Carbon Pools in the Santa Fe River Watershed

Soil spectral sensing for prediction of soil carbon pools is currently being evaluated in the Santa Fe River watershed. Funding for this project is provided by Natural Resources Conservation Service (NRCS) - Cooperative Ecosystem Study Unit (CESU) with S. Grunwald, N.B. Comerford, and J.O. Sickman as the investigators. In this project a quantitative geospatial framework is being used to assess soil carbon pools (total, mineralizable, hydrolysable, hot water extractable and recalcitrant), their linkages to mineralizable nitrogen and phosphorus and environmental landscape properties. The carbon, nitrogen and phosphorus pools are being integrated into a holistic soil-landscape model cutting across a variety of ecosystem types in the Santa Fe River Watershed. Site-specific observations are being upscaled to the watershed scale (3,585 km^2) using GIS and advanced geostatistical methods and synergized into a Geospatial Soil Knowledge Management System.

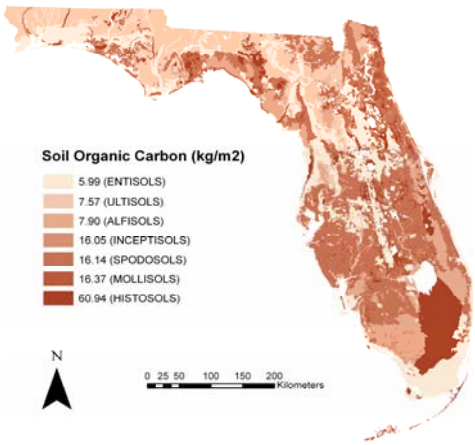
Aja Stoppe, graduate student in the Forest Soils Laboratory, soil sampling for C in the Santa Fe River Watershed

A spectral library in the visible/near-infrared range for various soil properties has been developed for the Santa Fe River Watershed. The spectral library can be used for rapid, accurate predictions of soil properties that are cheaper than conventional lab analysis. The potential application of cost-effective spectral mapping of large soil-landscapes is tremendous.

The project has also looked at the mineralizability of soil carbon in soil size fractions and shown that land use (vegetation x management interactions) has a noteworthy influence on the lability of soil carbon; with soil carbon under annual cropping systems being almost two times more mineralizable per gram of carbon than that under forested ecosystems. These studies are providing us with a better insight into how land management can protect soil carbon from decomposition and what are the labile pools of carbon in our unique soils.

For additional information, contact: Sabine Grunwald at sabgru@ufl.edu.

Rapid Assessment and Trajectory Modeling of Changes in Soil Carbon across Florida



Soil Organic Carbon Distribution in Florida (G.M. Vasques and S. Grunwald)

SWSD faculty were recently awarded a USDA-NRI grant to investigate the **Rapid Assessment and Trajectory Modeling of Changes in Soil Carbon across Florida**. The investigators are S. Grunwald, N.B. Comerford, W.G. Harris and G.L. Bruland (University of Hawaii). The goal of this research is to assess the effects of land cover/land use (LC/LU) change on carbon stocks giving special attention to translating site-specific carbon pools (labile, recalcitrant and total carbon) to landscape scales. Study objectives are comprehensive and range from, but not limited to: determining soil carbon pools in various ecosystem types across a large southeastern landscape (Florida); to investigating the strength and magnitude of relationships between environmental landscape properties and corresponding carbon pools within a GIS; upscaling soil carbon pools to the landscape scale by modeling spatial autocorrelations and covariations with environmental landscape properties. The studies data base will be comprehensive, including historic (~1,300 soil samples) and reconnaissance (~1,000) soil samples taken from throughout the state.

The story of soil carbon in Florida is not complete without considering the Everglades. In addition to the abundant historic data already published by the Wetlands Biogeochemistry Laboratory in the SWSD, a new project will be looking specifically at soil carbon in the floc/detritus and topsoil of parts of the Everglades. The project, **Remote-sensing Supported Digital Soil Mapping in South Florida**, is being funded by NRCS-CESU with S. Grunwald and N.B. Comerford as investigators. This study will add to the comprehensive inventory of soil carbon in a vast portion of the Everglades that has already been the subject of research within our department and incorporate Remote-sensing in the upscaling of the results. For additional information, contact: Sabine Grunwald at sabgru@ufl.edu.

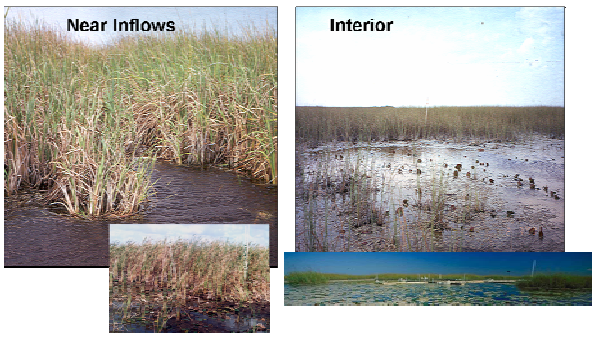
Influence of Water Levels on Subsidence of Organic Soils in the Upper St. Johns River Basin

The accumulation of the characteristic organic soils of the Upper St. Johns River Basin (USJRB) has taken several thousand years. The stability of these soils is highly dependent on hydrology as their formation is due to the historically extended hydroperiod of the USJRB floodplain wetlands. In some regions of the USJRB, the hydrology of the floodplain has been dramatically altered, resulting in substantial loss of organic soil. The main goal of this research was to determine the minimum water levels in wetlands needed to prevent net loss of organic soils that eventually leads to subsidence of soils in the Blue Cypress Marsh (BCM) of USRB. This was achieved by investigating the effect of water drawdown on soils with different vegetation type, temperature and nutrient levels. The effect was determined by measuring microbial activities such as aerobic and anaerobic respiration, methane production, phenol oxidase activity and β glucosidase enzyme activities. This research was supported by the St. Johns River Water Management District. The investigators are: Matt Fisher, Kanika Inglett, Todd Osborne, and K. Ramesh Reddy.

Matt Fisher from the St. Johns River Water Management District, collecting soil cores at the Blue Cypress Marsh site.

Results of this study showed that organic soils in the BCMCA are subject to impact with respect to water level drawdown. Carbon dioxide flux studies suggest that the surface 10 cm of soil is the most reactive and requires protection from subsidence due to oxidation when water levels are low. Soils in the BCMCA are also characteristically variable with respect to soil lability, dominant vegetation type, and site nutrient status, therefore responses to subsidence inducing low water events is site dependant. Microbially mediated oxidation is the primary driver of organic soil subsidence, and while shrinkage and compaction due to dewatering can have an effect, the long term losses of organic carbon due to oxidation are the most critical threat. This study provides evidence that suggests any drawdown even resulting in water levels below the soil surface can result in increased soil organic matter losses to oxidation and that these losses will be variable across the landscape given variation in soil nutrient availability and organic matter quality. For additional information, contact: K. Ramesh Reddy at krr@ufl.edu.

Controls on Methanogenesis in the Florida Everglades



Everglades Water Conservation Area-2A Ecosystem Alteration

Freshwater wetlands are among the most productive ecosystems in the world and provide a range of vital ecosystem services, including habitat for diverse plant and animal species and processes related to water quality and carbon storage. The terminal process of the carbon cycle is mineralization to either carbon dioxide or methane, and the specific routes through which carbon is funneled to these end products may be complex and linked to other cycles, such as the sulfur cycle. Both carbon dioxide and methane are green house gases, with methane being most potent of the two. Natural wetlands account for over 20% of global methane produced, such that a detailed understanding of the pathways leading to methanogenesis, and of the mechanisms through which eutrophication impacts these pathways, is crucial to understanding the impact of nutrient enrichment on ecosystem processes in wetlands and to developing ecosystem and global models of methane flux.

Results of a recently completed NSF funded project (Andy Ogram and K. R. Reddy) showed that ratios of rates of potential hydrogenotrophic methanogenesis to potential acetoclastic methanogenesis rates are much higher in the nutrient enriched soils than in the oligotrophic soils. Most probable numbers of hydrogenotrophic methanogens are over 1000 times greater than acetoclastic methanogens in nutrient enriched soils, and less than 100 times greater in oligotrophic soils. In addition, the dominant microbial groups controlling fermentation, methanogenesis and sulfate reduction exhibit different physiological characteristics with regard to acetate metabolism in the different soils, strongly suggesting different pathways for consumption of acetate and routes for methanogenesis as a function of nutrient enrichment. Results of this study have major implications on pathways and microbial communities involved in methane emissions from eutrophic wetlands. For additional information, contact: Andy Ogram at aogram@ufl.edu.

Carbon Sequestration of Agroforestry Systems

Carbon sequestration potential of agroforestry systems is attracting worldwide attention following the recognition of agroforestry as an activity for carbon sequestration under the Kyoto Protocol. This is a major theme for the research team of Vimala Nair (SWSD) and P.K. Nair (School of Forest Resources and Conservation, affiliate SWSD faculty). Through their collaboration with graduate students and overseas scientists, the widely believed, but largely untested, premise that agroforestry systems will retain more stable soil carbon than arable copping and pasture systems is being investigated. The systems under investigation include silvopastoral agroforestry systems in Florida; traditional and improved agroforestry systems in Mali, West Africa; homegarden systems in Kerala, India; and extensive (existing) as well as intensive (experimental) silvopastoral systems in northern Spain.

Carbon sequestration studies at a silvopastoral site at the Range Cattle Research and Education Center in Ona, Florida (Photo credit: Solomon Haile)

Carbon sequestration studies at a *Faidhelbia albida* dominant parkland system in Mali, West Africa (Photo credit: Asako Takimoto)

Soil carbon storage in different particle-size fractions at varying depths is being investigated, and wherever appropriate, the carbon source is being identified as being from the tree or the crop/grass (herbaceous) through the use of $^{13}C/^{12}C$ isotopic ratios. Additional investigations of this nature are planned for 2007 – 2008 from the silvopastoral system in the Cerrado region and the multistrata agroforestry system in the humid tropical lowlands, both in Brazil, through the involvement of visiting Brazilian scientists. For additional information, contact: Vimala Nair at vdn@ufl.edu .

Vimala Nair discussing the potential for carbon sequestration studies with host Dr. Mosquera-Losada at the forestry experimental site in Lugo, Spain.

Carbon sequestration studies in a homegarden in Kerala, India (from left to right: Subharjit Saha, two of the owners of the homegarden, and Dr. Kumar, local host in Kerala, India

Soil Accretion Dynamics in the Florida Everglades

Findings from a 3-year investigation of Shark River Slough in the Florida Everglades suggest a complex relationship between C assimilation and litter decomposition rates that regulates local soil elevation differences. Most changes in soil elevation of this area are due to an accumulation of organic plant litter and inorganic calcium carbonate in the form of Marl. It was first hypothesized that soil accretion rates would be greater on ridges than that on lower elevation sloughs. It was found that biomass production was greater and plant litter quality more recalcitrant (tissue C:N and lignin:cellulose ratios) on sawgrass dominated ridges than in sloughs suggesting a greater accretion rate of soils on ridges. However, due to the higher elevation of ridges, soils are exposed to the atmosphere more frequently and for longer periods increasing decomposition rates. As a result, although litter input was greater and more recalcitrant on ridges, greater decomposition rates appear to result in long-term soil accretion on ridges being almost equal to that of adjacent sloughs. This suggests that a dynamic equilibrium exists between C input potential and the duration of flooding, where periods of greater soil accretion on ridges can occur when hydrologic conditions allow (wet years). However, ridge elevation can only get so high relative to slough bottoms due to hydrologic feedback mechanisms causing ridge tops to become exposed and undergo decomposition. As long as the ridge community maintains a greater potential for soil accretion than that of sloughs, some relative difference in elevation between ridges and sloughs can occur. Maintaining differences in soil elevation are fundamental to preserving the ridge slough vegetative mosaic, a critical habitat and landscape feature of the Florida Everglades. For additional information, contact: Mark Clark at clarkmw@ifas.ufl.edu

Graduate Student Chris Lewis prepares samples after being dropped off by helicopter within Everglades National Park.

Low Impact Development Training

The Low Impact Development Training Initiative received a Promising Practice award from the Council for Sustainable Florida in June 2007. This award acknowledges innovative programs that "create a sustainable economic, environmental, and social future for Florida." The award was presented to **Mark Clark** representing the Program for Resource Efficient Communities (PREC) along with Linda Burnette and Gene Caputo both from the St. Johns River Water Management District. The Low Impact Development Training Initiative is a 6-hour workshop targeting local county governments to raise awareness of development impacts and provides guidance on more sustainable development alternatives. The Program for Resource Efficient Communities is a multidisciplinary effort of UF faculty from 5 departments that was initiated and is coordinated by the Florida Energy Extension Service, Directed by Pierce Jones. For additional information, contact: Mark Clark at clarkmw@ifas.ufl.edu or go to http://www.buildgreen.ufl.edu

SWS Alumni

In our newsletter, we would like to include news from our alumni and their success stories and accomplishments. Please provide highlights of your current activities, so we can include them in future SWSD newsletters. Please e-mail information and a photograph to Susan Curry at: scurry@ufl.edu.

FACULTY, STAFF & STUDENTS

Faculty, Students & Staff News

PURC Water Utility Benchmarking in Mexico

Julie Padowski delivered an invited presentation, "Survey of Benchmarking Methodologies: Improving Water Utility Efficiency" this summer at the "Seminario Internacional de Gestión y Regulación de los Servicios de Agua Potable y Saneamiento: La Experiencia Mexicana e Internacional" in Mexico City in coordination with the Public Utility Research Center at UF. Her talk emphasized the need for improved efficiency within water utilities and a stronger link between water resource managers and water utility managers in order to promote long-term sustainable water use. The event was organized by local institutions and organizations and attracted water utility managers, consultants, academics and regulators from Mexico and around the world to share ideas and discuss problems associated with the legal and institutional framework of water and sanitation services.

Congratulations… Summer 2007 Graduates

PhD

Daniel Herrera, Advisor, W. Harris
Kamal Mahmoud, Advisor, P. Nkedi-Kizza
Daniel Perkins, Advisor, J. Jawitz

MS

Erin Atkinson, Advisor, J. Jawitz
Miguel Mozdzen, Advisor, P. C. Wilson

The following students were awarded Grinter Fellowships for their PhD programs:

Edmund Azah (L. Ma)
Alex Cheesman (K. R. Reddy)
Augustine Obour (M. Silveira and G. O'Connor)
Shiny Mathews (L. Ma)
Augustine Muwamba (P. Nkedi-Kizza)

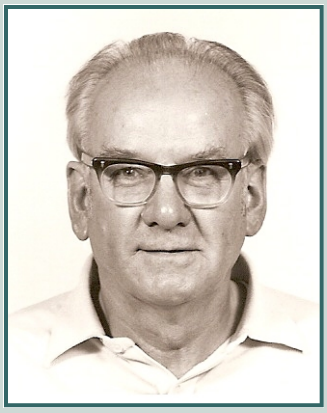
Debolina Chakraborty (V.D. Nair) and **Gustavo Vasques** (S. Grunwald) were awarded Alumni Awards to pursue PhDs.

Welcome… Incoming Students

Fall 2007

Rotem Shahar, MS, T. Obreza
Augustine Obour, PhD, M. Silveira/G. O'Connor
Debolina Chakraborty, PhD, V. Nair
Edmund Azah, PhD, L. Ma
Ronald Gonzalez, PhD, J. Sartain
Shawna Loper, MS, A. Shober
Xiaolin Sui, MS, M. Silveira
Lori Clark, MS, T. Obreza
Matthew Wilson, MS, E. Hanlon
Stephen Hanks, MS, C. Fitz
Robert Compitello, MS, T. Osborne
Pauric Mc Groary, PhD, G. Snyder
Neil Young, MS, G. Snyder
Erin Yancey, MS, J. Thomas
Melinda Hooper, MS, L. R. Ellis
Laura Sadowski, MS, J. Sartain
Daniel Moura, MS, M. Silveira/G. O'Connor
Tanya Scheff, MS, L. R. Ellis
Kristin Wheeler, MS, S. Newman
Marti Occhipinti, MS, G. Toor
R. Drew Lindemann, MS, S. Daroub

In Memoriam



DR. EARL LEWIS STONE, JR.

Earl Stone, 92, passed away July 23, 2007 in Gainesville, FL. He was born July 12, 1915 in Hinmansville, NY. He received his BS in forestry from the New York State College of Forestry at Syracuse in 1938, and his MS in soil science from the University of Wisconsin in 1940. He then worked as a forester with the US Forest Service. From 1942 to 1945 Dr. Stone served with the 8th Photographic Reconnaissance Squadron, 5th Air Force, in the SW Pacific. He received his PhD in soil science from Cornell University in 1948, and was appointed to the Charles Lathrop Pack professorship in forest soils in the Department of Agronomy at Cornell. Dr. Stone conducted research and teaching on effects of soil properties on forest type and growth; tree root mycorrhizae; soil fertility and forest ecology; element accumulation under forests; and ecology of the forest floor.

Upon retiring from Cornell in 1979, Dr. Stone joined the University of Florida as adjunct professor of soil science, with an affiliate appointment in UF's School of Forest Resources and Conservation. He remained active in research, writing, and mentoring of graduate students until 2002.

Dr. Stone took on numerous scientific/professional assignments during his career, including visiting associate professor of forestry at the University of the Philippines; Fullbright senior research fellow at the Forest Research Institute, Rotorua, NZ; visiting professor (Thailand) for Oregon State University; consultant to the National Institute of Biology, Bogor, Indonesia; consultant to the President's Advisory Panel on Timber and the Environment; and member of the Bikini Atoll Rehabilitation Committee. Dr. Stone was widely published and much sought-after as a keynote speaker and writer of comprehensive articles. He was a Fellow of the American Association for the Advancement of Science, the Society of American Foresters, SSSA, and ASA. He twice served as chair of Division S-7, and served on numerous editorial panels.

Dr. Stone was predeceased by his wife of 56 years, Margaret H. Stone, and by his second wife, Jean LaChance Stone. He is survived by a brother, three children, and five grandchildren. Contributions may be sent in memory of Earl Stone to the Charles Lathrop Pack Forestry Trust, PO Box 2600, Ithaca, NY 14850. Sympathies may be conveyed to Earl Stone III, 911 Grants Pkwy, Arlington, TX 76014.

Plan to attend...

University of Florida and Progress Energy partner to host the

First UF Water Institute Symposium

Sustainable Water Resources

Florida Challenges, Global Solutions

February 27-28, 2008

Hilton University of Florida Conference Center

Gainesville, Florida